Computer Sciences Corporation
System Sciences Division

This is the closing report for NASA contract NAG5-31849 (Task 5785), SHORE, S. N. (PI). A partial list of papers related to IUE research supported under this contract is provided below. Two graduate students were partially supported on this research. Isabelle Waxin (Univ. of Paris VII and New Mexico Tech) and Dake Zhang (New Mexico Tech). Waxin completed a study of AG Car and HR Car, galactic luminous blue variables, and the paper on this is now being prepared for submission (Shore, Waxin, and Altner 1995, in preparation). Partial results were reported in Shore (1993) and also in several colloquia. Zhang began a study of the coliding winds in V444 Cyg before leaving graduate school in 1992. As a result, this work was not completed, although some preliminary results have been reported in Shore (1994, Saas-Fee), sufficiently detailed results were obtained to confirm the earlier work by Shore and Brown (1988, ApJ) on the colliding winds in these systems. Alexander Lopatnikov Moscow) also worked with Shore during this period on problems related to evolution of massive stars in the Galaxy, specifically relating the dynamical information obtained from the IUE observations to the study of stimulated star formation. These results are partially reported in a book by Shore and Ferrini (1995, Fund. Cosm. Phys., in press) and also will be the subject of a separate paper.

The founding work of the binary star portion of this program was the paper by Shore, S. N. and Brown, D. N. 1988, *Ap.J.*, **334**, 1021: "Colliding Stellar Winds in the Wolf-Rayet Binary Star V444 Cygni". This served as the basis for the two papers by Shore and Corcoran (1992) and Corcoran *et al.* (1993), both listed below. An additional paper on the combined x-ray and UV observations and modeling is in preparation. Some results from the IUE study were included in Shore (1992, *Introduction to Astrophysical Hydrodynamics*) for which NASA support was acknowledged,

1. Michalitsianos, A. G., Kafatos, M., and Shore, S. N. 1989, *Ap. J.*, **341**, 365: "Sanduleak's Star (LMC Anon) in the Large Magellanic Cloud: Its Similarity in the Far UV with the Massive Luminous Supergiant η Carinae".

2. Grady, C. A., Bjorkman, K. S., Snow, T. P., Sonneborn, G., Shore, S. N., and Barker, P. K. 1989, *Ap.J.* **339**, 403: "Highly Ionized Stellar Winds in Be Stars. II. Winds in B6 - B9.5e Stars".

3. Shore, S. N., Brown, D. N., Sonneborn, G., Landstreet, J. D., and Bohlender, D. A. 1990, *Ap. J.*, **348**, 242: "The Discovery of Magnetically Controlled Circumstellar Plasma in the Helium Weak Stars HD 5737 and HD 79158".

4. Shore, S. N., Brown, D. N., Bopp, B. W., Robinson, C. R., Sanduleak, N., and Feldman, P. D. 1990, *Ap. J. Suppl.*, **73**, 461: "A Multiwavelength Study of the Carlson - Henize Sample of Early - type Galactic Extreme Emission-Line Stars".

5. Eaton, J. A., Kondo, Y., McCluskey, G. E., and Shore, S. N. 1990, *A. J.*, **100**, 799: "The Long-Period Binary AL Velorum: The Atmospheric Eclipse of a K0 III Giant".

6. Shore, S. N., and Brown, D. N. 1990, *Ap. J.*, **365**, 665: "Magnetically Controlled Circumstellar Matter in the Helium-Strong Stars".

7. Gurzadyan, G. A., Cholakyan, V. G., Kondo, Y., Terzian, Y., and Shore, S. N. 1990, *P.A.S.P.*, **102**, 1387: "The Mg II h and k Interstellar Lines in the Spectrum of the G-type Giant HD 156854".

8. Massa, D., Shore, S. N., and Wynne, D. 1992, *Astr. Ap.*, **264**, 169: "Photospheric Velocity Gradients in B1 Supergiants".

9. Michalitsianos, A. G., Perez, M., Shore, S. N., Maran, S. P., Sonneborn, G., Webb, J. R., Oliversen, R. J., and Starrfield, S. G. 1993, *Ap. J. Letters*, **409**, L53: "Ultraviolet Continuum Variability and Visual Flickering in the Peculiar Object MWC 560".

10. Shore, S. N. and Aufdenberg, J. 1993, *Ap. J.*, **416**, 355: "On the Interpretation of the Ultraviolet Spectra of Symbiotic Stars and Recurrent Novae. I.".

11. Sion, E. M., Shore, S. N., Ready, C. J., and Scheible, M. P. 1993, *AJ*, **106**, 2118: "The Onset of Wolf-Rayet Wind Outflow and the Nature of the Hot Component in the Symbiotic Nova PU Vulpeculae".

12. Shore, S. N., van den Heuvel, E., and Livio, M. 1994, *Interacting Binary Stars: 22nd Advanced Course, Swiss Society of Astronomy and Astrophysics - Saas Fee* (eds. Nussbaumer, H. and Orr, A.) (Berlin: Springer-Verlag), *in press.* Collected lectures, Chapter 1, p. 1-135: "Observations of Physical Processes in Binary Star Systems".

13. Shore, S. N. 1992, *An Introduction to Astrophysical Hydrodynamics* (San Diego: Academic Press). 452 pp. (senior-graduate level text).

14. Wu, C.-C., Reichert, G. A., Ake, T. B., Boggess, A., Holm, A. V., Imhoff, C. L., Kondo, Y., Mead, J. M., and Shore, S. N. 1992, *International Ultraviolet Explorer (IUE) Ultraviolet Spectral Atlas of Selected Astronomical Objects* (NASA Ref. Publ. 1285), iv + 421 pp.

15. Shore, S. N. 1995, in *Astrophysical Quantities: 4th Edition* (ed. Cox, A. N.) (NY: AIP Press) *in preparation*: Cataclysmic Variables and Related Stars: sections on symbiotic stars and Galactic and LMC novae.

16. Shore, S. N. 1989, in *IAU Colloquium 113: Physics of Luminous Blue Variables* (eds. Davidson, K., Moffatt, A. F., and Lamers, H. J. G. L. M.) (Dordrecht: Kleuwer) pp. 51-58: "An Ultraviolet View of the LBVs in the Galaxy and the Magellanic Clouds".

17. Shore, S. N. 1992, in *Objective Prism and Other Surveys: A Memorial to Nicholas Sanduleak* (ed. Philip, A. G. D. and Upgren, A.) (Schenectedy: L. Davis Press), pp. 103-113: "The Luminous Blue Variables and Final Evolution of the Most Massive Stars".

18. Shore, S. N. 1992, in *Nonisotropic and Variable Mass Outflows From Stars: STScI Workshop* (eds. Drissen, L., Leitherer, C., and Nota, A.) (San Francisco ASP Press), pp. 342-352: "The Luminous Blue Variables in the Ultraviolet".

19. Shore, S. N. 1993, in *Massive Stars: Their Lives in the Interstellar Medium* (ed. Cassinelli, J. and Churchwell, E.) (San Francisco: ASP Press), pp. 186-198: "The Perplexing Variety of Massive Stars and their Relation to the Interstellar Medium".

20. Shore, S. N. 1994, in *First International Meeting on Herbig Ae/Be Stars* (eds. Perez, M. and van den Heuvel, E.) (San francisco: ASP Conf. Series vol. 62), pp. 305-314: "Massive Binary Systems Among the Herbig Ae/Be Stars: Whence, Whither, and How?"

21. Shore, S. N. 1990, in *Evolution in Astrophysics: IUE in the Era of New Space Missions* (ed. E. Rolfs) (ESA SP): "The Helium Strong Stars of the Orion OB1 Association".

22. Shore, S. N. and Corcoran, M. F. 1992, in *IAU Symp. 151: Evolutionary Processes in Interacting Binary Systems* (eds. Kondo, Y., *et al.*) (Dordrecht: Kluwer), p. 359: "Colliding Stellar Winds: Theory and Observation".

23. Shore, S. N., Michalitsianos, A. G., and Kafatos, M. 1992, in *Anisotropic Mass Outflow from Stars: STScI Workshop* (eds. Drissen, L., Leitherer, C., and Nota, A.) (San Francisco: ASP Press): "Long Slit Ultraviolet Spectroscopy of the Circumstellar Environment of the Symbiotic Star R Aquarii".

24. Corcoran, M. F., Shore, S. N., Swank, J. H., Heap, S. R., Rawley, G. L., Pollack, A. M., and Stevens, I. 1993, in *Massive Stars: Their Lives in the Interstellar Medium* (ed. Cassinelli, J. and Churchwell, E.) (San Francisco: ASP Press): "X-ray Variability in V444 Cygni – Evidence for Colliding Winds".